Supplemental Response
Delta Vision Task Force Request for Agricultural Water Use Efficiency Information

California Department of Food and Agriculture
October 10, 2008

Delta Vision requested that the Department of Food and Agriculture (CDFA) provide information related to agricultural water use efficiency (WUE) in California. Specifically, Delta Vision requested CDFA provide the following:

1. Policies and programs to achieve increased efficiency and conservation in the use of agricultural water supplies; and,

2. Patterns of agricultural water use for the state as a whole and regionally, if available for a record of 50-years.

During our research, we learned that this request was also made of the Department of Water Resources (DWR). We believe that DWR, as the state agency responsible for planning and management of state's water resources, is best equipped with the data and expertise to take the lead in responding to this request. DWR prepared a response with our contributions on programs and policy. Thus, the submittal is a jointly authored response.

In addition to the collaborative response submitted via DWR, we offer the following supplemental information regarding agricultural water usage, which was developed from agricultural production surveys and assumed water use efficiencies. Raw water delivery information is available from the major water projects (e.g. CVP) but neither this information nor the developed water use information reveals patterns and trends in agricultural WUE. Water delivery information does not account for transmission losses, the multiple reuses of water, water transfers, or the dynamic nature of agriculture such as land fallowing, changing land use, and crop shifting. Crop shifting, while improving agricultural WUE, has not necessarily resulted in less water use. Thus, conclusions regarding trends in agricultural WUE, or inferences of agricultural water use cannot be derived from water delivery information.

With this supplement to the aforementioned DWR/CDFA response, we assembled information that provides insights into the trends and patterns in agricultural WUE. Given the limited time, this is not an exhaustive review but gives a flavor for the efforts and challenges faced by the California agricultural industry in managing limited and uncertain water supplies. In addition, we have attached several articles that address the very important concepts and myths surrounding agricultural irrigation efficiency.

<u>Trends in Irrigation Methods</u>
To get at the question of agricultural WUE we present information in trends on irrigation management including irrigation methods and systems performance. We also identify the numerous incidents that have occurred over the last 20-years either through legislation,

regulation, or agreements and compacts that have resulted in large shifts in agricultural water supplies to the environment and urban sector. We will also highlight some of the especially impacted regions and review how they have been affected by reduced agricultural water supplies, and how growers are adapting.

Irrigation method has a large effect on agricultural WUE providing that the systems are being managed optimally. The Distribution Uniformity (DU) is a measure of how uniformly irrigation water is applied across the field and an indicator of system performance and agricultural WUE. All things being equal, the average distribution uniformity values for surface, sprinkler, and drip/micro-irrigation are approximately 0.70, 0.75, and 0.80, respectively (CALFED, 2006). Thus, a shift from surface irrigation methods (e.g. furrow, basin flood) to pressurized (e.g. sprinklers), and low volume methods (e.g. drip and micro-irrigation) is an indicator of improving agricultural WUE. However, the shift from surface to low volume has a significant capital and net energy cost.

The most comprehensive review of irrigation methods trend was undertaken by DWR in connection with the 2005 Water Plan Update and also published in Orang et al. (2008). In this study a comprehensive survey was undertaken of California farmers. Surveys were provided to a large random sampling of California farmers (17%) as to cropping patterns and irrigation methods. The result of this survey was compared with earlier surveys conducted in 1972, 1980, and 1991. The findings are summarized in Tables 1 and 2.

Table 1[1]: Percentage of irrigated land by crop categories and irrigation methods (1991)

Irrigation Methods	Field	Vegetables	Orchard	Vineyard	All Crops
Gravity	89.3	70.9	31.6	44.9	66.9
Sprinkler	9.4	19.8	32.1	12.6	17.3
Low Volume	0.3	9.3	36.1	42.3	15.2
Subsurface	1.0	0	0.2	0.3	0.6
Total	100	100	100	100	100

Table 2[1]: Percentage of irrigated land by crop categories and irrigation methods in 2001

Irrigation Methods	Field	Vegetables	Orchard	Vineyard	All Crops
Gravity	83.6	42.9	20.3	20.8	49.6
Sprinkler	12.3	36.0	16.2	8.7	15.7
Low Volume	0.1	21.1	63.0	70.2	32.9
Subsurface	4.0	0	0.4	0.2	1.8
Total	100	100	100	100	100

[1] DWR, 2005

Tables 1 and 2 demonstrate that in a 10-year period a large shift toward more efficient irrigation methods for all crop types. In this period, the area under highly efficient low volume irrigation more than doubled to 33 percent of the irrigated acreage; correspondingly, the acreage under surface irrigation decreased by 26%. The longer term trends are depicted in Figure 1. This survey was conducted in 2001 however, it appears this trend continues and the use of micro-irrigation is spreading to field crops such as cotton, processing tomatoes, and potatoes (Blake Sanden, personal communications). This trend has been fueled mainly by the large shift to orchards, primarily almonds and pistachio from field crops. Figure 2 shows the shift in crop production from field crops to orchards. This shift has facilitated the increase in use of low volume irrigation systems. Nut crops such as almonds and pistachios provide a higher return to farmers, which allows the farmer to invest in capital intensive irrigation low volume irrigation systems.

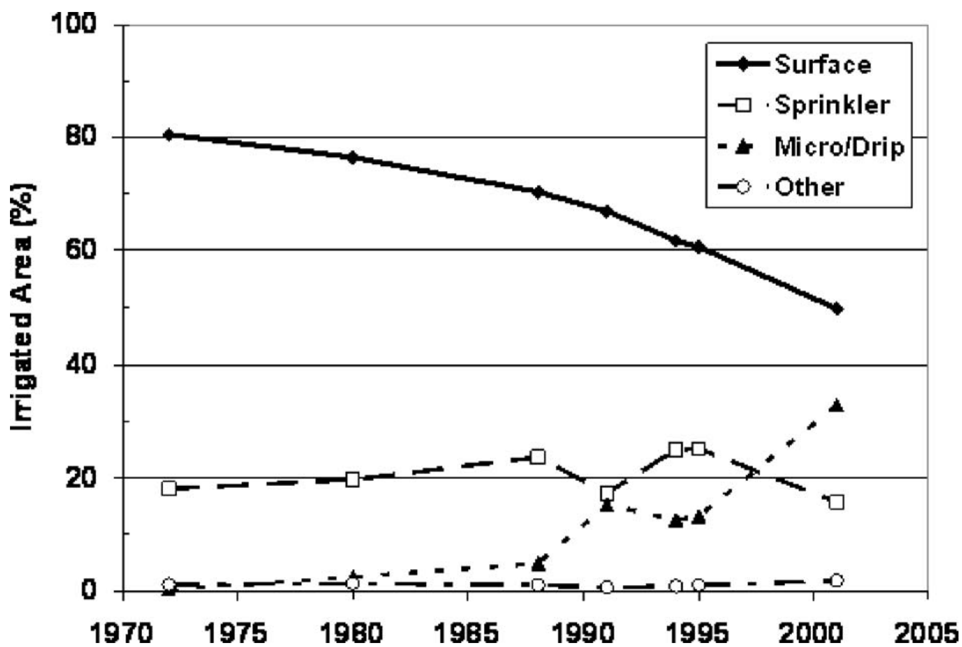

Figure 1[2]: Trends in irrigated area (%) by irrigation method

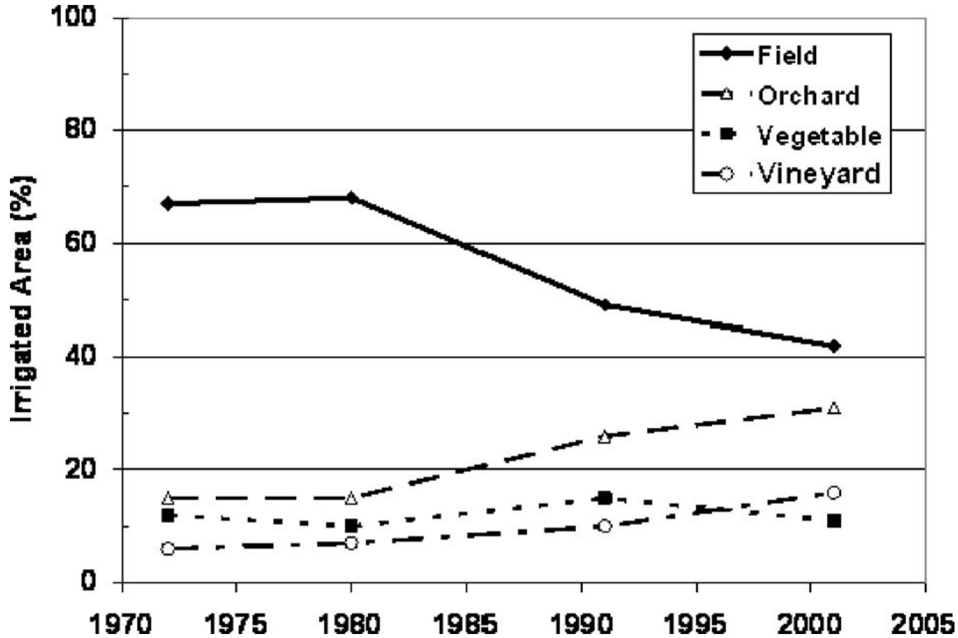

Figure 2[2]: Trends in percent irrigated area by crop category

In the 2001 survey (DWR, 2005), 70% of the vineyards, and 69% of the almonds and pistachio acreage was being irrigated by low volume irrigation. In some counties such as Kern, the acreage under low volume irrigation may be in the order of 80 to 85% (Blake Sanden, personal communications). The survey also showed that two percent of the processing tomato acreage was being irrigated by low volume irrigation. Though, we are not familiar with any formal survey, the acreage of processing tomatoes under low volume has changed dramatically in recent years. However, in 2008, Hartz, et al. noted that 20% of processing tomato acreage is under drip and increasing rapidly. The J. G. Boswell Company, which has approximately 26,000 acres of processing tomatoes in the San Joaquin Valley, is reported to have all of its production under drip irrigation (Blaine Hanson , personal communications). Nowhere is the trend toward drip irrigated processing tomatoes more apparent than in the Westlands Water District service area. According to Netafim, a provider of drip irrigation supplies, in the past five to seven years, the company provided sub-surface drip systems for 40,000 acres, mainly for processing tomatoes. This is just one of several companies that provide low volume irrigation supplies (Los Banos Enterprise – September 19, 2008), but an indictor nonetheless.

This trend of increasing production of processing tomatoes under drip irrigation has been spurred by the research of Blaine Hanson, irrigation specialist at UC Davis, where he has devised a management strategy to maintain high levels of processing tomato production

[2] Orang et al., 2008

using drip irrigation over a shallow (24 inches) saline groundwater. Irrigating at 100 percent reference evapo-transpiration produces a leaching fraction of 25 percent and no additional sub-surface drainage (Hanson and May, 2006). Yields on drainage impaired and saline lands are a respectful 40 tons per acre.

Trends in changing irrigation methods toward low volume systems from surface systems demonstrated by Orang et al. are confirmed in a survey by Dillon et al. In their survey of 42 counties and 800 respondents, Dillon et al. found an 11 percent decrease in acreage irrigated by surface irrigation methods and 12 percent increase in acreage irrigated with low volume methods.

In Tehama County, Fulton (personal communications) reports that since the mid-1990s, virtually all new irrigation systems in orchards are low volume. He also notes that in the last two decades, there have been large shifts from row crops, forage, and pastures that historically were flood irrigated to orchard crops irrigated with low volume systems.

<u>Irrigation System Efficiency</u>
As was noted, Distribution Uniformity (DU) is a measure of how uniformly irrigation water is applied across the field and indicator of system performance and agricultural WUE. One such example is in Mendocino County where the Mendocino County Water Agency contracted with UC Cooperative Extension to estimate agricultural water demand on a portion of the Russian River watershed. Among the tasks of this undertaking was a field evaluation and measurement of existing irrigation systems on a subset of vineyards, pear orchards, and irrigated pastures to understand consumptive water use and system distribution uniformity. Results of irrigation system performance are summarized on Table 3.

Table 3: Summary of irrigation system performance in Mendocino County

Crop	mean	Std Dev	Minimum	Maximum
Grapes (n = 33)	88.8	7.5	64.3	96.0
Pears (n = 7)	88.4	5.5	81.9	94.3

These are very high levels of performance. A survey done for the analysis showed that growers had adopted water efficient irrigation systems, including drip for vineyards (90 percent of acreage), under-canopy sprinkler systems in pear orchards, and gravity type underground pipe and valve or sprinkler delivery systems in irrigated pastures.

Information was also obtained for Sacramento Valley from Allen Fulton, irrigation specialist for Tehama County. In the 5-year period between 2002 and 2007, 191 irrigation system evaluations were performed by the Tehama County Resource Conservation District – Irrigation Mobile Lab. While the majority of the evaluations were conducted in Tehama County, other counties in the Sacramento Valley were also included. Crop types evaluated included orchards (walnuts, almonds, prunes, olives, figs, and apples), field crops (alfalfa) and berries. Results found an average DU of 84 percent, with a range of 13-98 percent (Allen Fulton, personal communications).

Farm Level WUE

Assessment of farm level WUE efficiency was conducted in Kern County by the UC Cooperative Extension and the Pond-Shafter-Wasco Resource Conservation District Irrigation Mobile Lab (Sanden et al, 2006). Farm level WUE was estimated by two methods. One was the theoretical water needs divided by the applied water. The second was by field measurements of soil moisture depletion as determined with neutron probes. The study covered 101 fields covering 8,687 acres, on 12 different crops and 11 soil series. Estimates by both methods were nearly identical, 96 percent (theoretical) versus 97 percent by soil moisture depletion. It should be noted that most of the fields were irrigated with low volume systems using expensive water and where growers were already practicing optimal or deficit irrigation.

Shifts in Agricultural Water Supplies

Over the last 20-years there have been a number of statutes, regulations, and agreements and compacts that have resulted in the large shifts in agricultural water supplies to the environmental and urban uses. These shifts have impacted some water suppliers greater than others. As a result, growers supplied by these water purveyors have had to take extraordinary measures to cope with the reduced water supplies. Below we provide a partial list, and where information is available, we note some of the impacts. In general, these incidents have resulted in large-scale land retirement with significant impacts to local economies. Due to the short-time frame, this list is not comprehensive or up-to-date with the more recent developments. Thus, this presentation under-estimates the actual impact of reduced water supplies in California. As an attachment, we have included information specific to the Klamath Basin. Similar information could have been developed for other hard-hit areas such as the Westlands Water District and the Imperial Irrigation District.

According to Dan Nelson, Executive Director of the San Luis Delta Mendota Water Authority in testimony to congress, since 1991 approximately 3.5 million acre-feet of Central Valley project water has been re-allocated for environmental purposes. As a result, south of Delta agricultural water contractors can only expect to receive 65 to 70 percent of their contract supplies under "normal" hydrologic conditions.

These reallocations have come about as a result of the following:

- Federal Endangered Species Act (listing as threatened of the Sacramento River winter run Chinook salmon, and the Delta smelt) re-allocated 300,000 acre-feet per year;
- The Central Valley Improvement Act reallocated 800,000 acre-feet per year for fish and wildlife and their habitat, and provided 410,000 acre-feet per year to the State and Federal wildlife refuge and wetlands.

- The Bay Delta Accords resulted in south of Delta agricultural water contractors voluntarily committing up to 500,000 acre-feet of water for environmental restoration efforts.
- The Trinity River Record of Decision.

To cope with the reduced water supplies, south of Delta farmers have undertaken measures and strategies including the following:

- Water conservation where there has been a shift to pressurized irrigation systems.
- Shift to higher value crops that will support the more capital-intensive irrigation systems.
- Water transfers both within and outside of the region.
- Groundwater utilization.
- Land retirement where water supplies from retired lands has been shifted to land remaining in production. This has resulted in 100,000 acres that have been permanently retired from agricultural production. Additionally, due to the current water supply conditions caused by the drought, and restricted Delta pumping, an additional 150,000 acres has been temporarily fallowed.
- In response to the chronic water supply shortage, the entire agricultural land of the Broadview Water District has been retired.
- Recycling of subsurface drainage for irrigation supplies and the purchase of large tracts of land for the purpose of utilizing highly saline drainage waters on salt tolerant crops.

Prior to 1991, water allocations to south of Delta agricultural contractors were reduced only twice in 40-years, both in response to the severe droughts (1977 and 1991). Since 1991, there have been only 3-years in which full allocation has been provided. As a result of the recent court ruling on the decline of the Delta smelt, water supplies to federal agricultural contractors were reduced to 45 percent. Then in June the US Bureau of Reclamation announced further reductions (a 5% reduction), and summer rationing due to Delta pumping restrictions. As a result, many farmers abandoned row crops and shifted the limited water supplies to orchards.

The 1995 Monterey Agreements provided for the resolution of the distribution of State Water Project water between agriculture and urban suppliers. In 1991, agricultural water purveyors received 0 percent of their allocations while urban received 20 percent. The Monterey agreements placed agriculture on even footing with urban users but required reductions in their annual entitlements by 45,000 acre-feet and transfers of 130,000 acre-feet to urban users in order to obtain this concession.

When fully implemented, the San Joaquin River Settlement Agreement will result, on average, in an annual reduction of 170,000 acre-feet of irrigation supplies to the Friant Unit of the CVP. These reductions are necessary for the restoration of flows to the lower

San Joaquin River from downstream of Friant Dam to the confluence of the Merced River for the purpose of restoring the salmon fisheries.

The Sacramento Valley Water Management Agreement is an agreement by the USBR, DWR, Sacramento Valley water interest, and the Delta water exporters for flows to achieve the water quality requirements in State Water Resources Control Board Delta Water Quality Control Plan. The plan relies on water management and efficiency improvements including conjunctive use to make available 185,000 acre-feet of water per year for this purpose. Half of this water will be used to meet water quality objectives in the Delta. Most of this water will be made available from Sacramento Valley agricultural water suppliers.

The Quantification Settlement Agreement (QSA) reached early in this decade, was undertaken in order to bring California back to within its long ago agreed upon allocation of 4.4 million acre-feet from the Colorado River. Prior to the QSA, California, primarily the Metropolitan Water District, had been exceeding its allocation by 800,000 acre-feet per year. Imperial Irrigation District (IID), a senior water right holder, conceded to this agreement under duress from the state and federal government. The QSA provides a process by which water from the IID will be transferred to urban water purveyors, including the San Diego Water Agency (200,000 acre-feet), and the Metropolitan Water District (MWD) and Coachella Water District (CWD) (100,000 acre-feet). Additionally, environmental mitigation for the transfers will be financed through the sale of transferred water from IID. Water for these transfers will be made through efficiency improvements by IID and through agricultural land fallowing.

The Palo Verde Irrigation District (PVID), an agricultural irrigation water purveyor, has entered into a water transfer agreement with MWD. This agreement calls for MWD to make a one-time payment to farmers willing to leave between seven to 29 percent of their land fallow at MWD's request. This arrangement will make between 25,000 to 111,000 acre-feet of water available to MWD and could fallow a maximum of 26,500 acres.

The listing of two sucker fish species in the Upper Klamath Lake and the Coho salmon in the Klamath River under the Federal ESA has resulted in cutbacks and uncertainty of irrigation water supplies to Klamath Basin farmers. In 2001, all irrigation water supplies were curtailed. A water bank for environmental purposes, primarily to enhance in-stream flows was established under the Biological Opinion and operations plan. This water bank is supplied with 100,000 acre-feet from mostly irrigation supplies. This amount accounts for between one-quarter and one-third of the agricultural water usage in the Klamath River Basin. For a case study of the Klamath Basin situation, see Attachment 1.

Due to the reduced water supplies for 2008 and the Delta smelt court decision, which curtailed pumping from the Delta, farmers served by the State Water Project and CVP have undertaken extraordinary measures. In southern California, avocado growers have been "stumping" (beheading) their trees, and as a result, will put the trees out of production for 1 to 3 years. This measure is being taken to provide adequate water for the remaining trees, and as a result of a 30 percent cutback in their water supplies by MWD as a first response to the reduced SWP water deliveries.

Conclusion

As the state of California struggles with the future of its critical water infrastructure it becomes clear that there is much more at stake than just the delivery and flow of water. The request from the Delta Vision Task Force to provide supplemental information on agricultural "water use efficiency" (WUE) has resulted in a preliminary discussion on the subject of agricultural water use. The concepts of irrigation efficiency and crop options are a starting point in determining what kind of role agriculture is to play in the future. The Supplemental Response offered here by the CDFA describes some of the wide range of conservation practices and efficiency programs that have been embraced by the farmers and ranchers in our state. The challenge comes with the fact that so few policy makers, and an even smaller amount of public leaders understand the tremendous advances and efforts made by agriculturists to wisely use their most critical resource…water. Today there exists a misconception that agriculture wastes water, or can do more with less. The farming practices of the 21st century will show that agriculture can little afford to waste any resource, whether it is water, soil, nutrients or labor. The statistical facts and studies continue to present a compelling picture of efficiency and innovation that have accelerated with the pressures of urbanization, environmental concerns, resource depletion and global competition. Agriculture is the epitome of adaptive management by mankind as he pushes away from a state of survival and tries to maintain a life of abundance. When farmers "stump" perfectly good avocado trees or abandon and fallow hundreds of thousands of acres, it is because there is an abundance of food and fiber in our society…not that there is a shortage of water. While this is not the case in countless developing countries, it is the case here in California. And the decisions that we make to keep our predictable supply of water, food, fiber and fuel in abundance is why this discussion about infrastructure must take place with our eyes wide open. The Delta Vision mandate is to find a solution set that can give us flexibility and predictability in our most important state water system. We have the short-term luxury of talking about what we might do…we have the long-term necessity of doing what we must.

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Attachment 1

Klamath Basin

Crisis struck in the spring of 2001 when irrigation water to more than 1,300 farms and ranches in the Klamath Basin was cut off for the entire growing season due to drought and impacts of the Endangered Species Act.

The Klamath Basin, located on the border between Oregon and California, covers slightly more than 10 million acres with roughly 3.7 million acres of private land, 6.2 million acres of public land, and 90,000 acres of tribal land. With over 2,000 farms operating on roughly 556,800 acres, the region produces oats, barley, wheat, potatoes, and sugar beets, fueling a $300 million agriculture-dependent economy.

Agricultural Impacts

The US Bureau of Reclamation estimates that 80% of the agricultural lands in the Klamath Basin are irrigated. Only about 220,000 acres, or half, of these are irrigated with Reclamation-supplied water. The project also provides water for two national wildlife refuges and fulfills obligations for the Native American Trust Assets in Oregon and California.

Upon the reallocation of water in the region, Federal, state and local interests mobilized, bringing financial and technical resources. Priorities included decreasing the amount of water needed for agriculture, increasing water storage, improving water quality, and developing fish and wildlife habitat.

From 2002 – 2007 USDA NRCS provided over $93 million to deliver a wide range of conservation - financial and technical assistance. Nearly $28 million was spent for wetlands including permanent easement enrollment of 21,000 acres – and habitat enhancement on nearly 9,000 acres. NRCS also provided assistance for the establishment of 41,000 acres of cover crops in the Basin to prevent erosion.

Local interests have worked with conservation groups like California Waterfowl Association (CWA) and Ducks Unlimited (DU) to take significant steps for the benefit of the wildlife refuges. A comprehensive wetlands-crop rotation plan for lease lands has been developed with support from local agriculture.

Local drainage and irrigation districts have also installed improvements using their own funding – resulting in reduced Klamath River water diversions, drought mitigation benefits, and improved canal delivery efficiency. Other improvements include the conversion of open-channel conveyance systems to subsurface piping systems. Canal-lining projects using a state-of-the-art canal lining material called Ethylene Propylene Diene Monomer were also undertaken. Over 400,000 square feet of this material was used to line nearly 2 ½ miles of open canal. Prior to the lining project, the yearly seepage loss in the canal was estimated at 1,000 acre-feet, resulting in significant water savings with relative ease of construction and maintenance. Reclamation also works with water purveyors to promote low-cost, “low-tech” lining systems which can be installed and maintained by irrigation district personnel without the need for specialized contractors.

Economic and Social Impacts
Oregon State University estimated the preliminary economic impact in the Upper Klamath Basin (UKB) at $157 million lost in total agricultural sales and an additional $79 million lost in reduced employment, proprietary income, and other property values. The water cutoff also severely impacted the local community.

Conflict, polarization and uncertainty about the future of agriculture led to frustration and fear, and a disruption of the fabric of life - social service agencies, schools, and local businesses were all affected (USDA NRCS).

Current Status
From 2005-2007, local stakeholders in the Klamath Basin have developed a proposed Klamath Basin Restoration Agreement (KBRA) intended to result in effective and durable solutions. The KBRA focuses on restoring and sustaining natural fish species production throughout the Klamath Basin; establishing reliable water and power supplies which sustain agricultural uses, communities, and National Wildlife Refuges; and, contributing to the public welfare and the sustainability of all Klamath Basin communities.

Currently, the Klamath Settlement Group is negotiating with PacifiCorp to reach agreement on the removal of the utility’s four lower dams on the Klamath River.

Sources:
Oregon State University
USDA NRCS
Klamath Water Users Association

Attachment 2

University of California Cooperative Extension

UC
CE

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How Good is Water Use Efficiency in California Agriculture?

According to a recent report by the Pacific Institute, which has been widely publicized, the answer is not very good. Now they didn't say it in exactly those words, but the point of the report was to say that as the biggest user of water in California (about 80% of water diverted out of rivers and the Delta and pumped from groundwater), the ag sector has the biggest potential to "free up" water to meet other needs by improving the efficiency of irrigation. This is not an unreasonable assumption as the biggest user usually has the most to save. The report outlines as much as 6.45 million acre-feet (MAF) per year of conservation savings could be generated through four different conservation scenarios. This is more than twice the water that the whole of Kern County uses in a year to irrigate more than 800,000 acres of fruits, nuts, vegetables and field crops. But we need to look at some significant in-field facts and the critical difference between 'on-farm' application water use efficiency (WUE) and net 'basin-wide' efficiency to see if this argument … holds water.

'On-farm' efficiency: For a given field, this is defined as the amount of water beneficially used (crop water use, transpiration, and the evaporation that occurs during irrigation, ET) plus any leaching requirement for salinity control divided by the total water applied. Say a farmer with an 80 acre alfalfa field using surface irrigation applied a total of 400 ac-ft of water (a 5 foot depth over the whole field) by pumping groundwater and using water supplied by the local water district. If the actual ET requirement of the crop was only a depth of 4 feet (320 ac-ft for the whole field) and we ignore the leaching requirement, then the 'on-farm' WUE of this field is 320/400 = 80%.

This would be considered a good level of efficiency for surface irrigation as listed in California's Water Plan Bulletin 160. This is about the average irrigation uniformity of 80.8% measured over 85 fields by the Northwest Kern Resource Conservation District Irrigation Mobile Lab from 1988 to 2005. By switching to center pivot sprinkler irrigation this farmer could possibly improve his uniformity and efficiency to 90% and improve his yields. Great! So if we use the same 4 foot crop requirement then the farmer only needs 320/0.9 = 355 ac-ft. So he "saves" 45 ac-ft, right? Not necessarily. The precision of the center pivot and much smaller application rate requires that you now irrigate the crop 5 to 10 times more often than the old surface system. This can reduce crop stress, which can increase yield by increasing transpiration. It also increases water lost to evaporation. The farmer's efficiency improves, but the real payback for the more expensive irrigation system is the increased yield. Final 'on-farm' WUE, in terms of the amount of crop per drop of water will probably be more than the old surface system.

'Basin-wide' efficiency: Using the above example, what happened to the extra 80 ac-ft of water the farmer applied to the field using the old surface irrigation system, but was not used by the crop? Maybe half to three-quarters of this is deep percolation – water that moves below the crop rootzone usually at the 'head' or high side of the field. This water goes down into the water table. For most fields in the Central Valley, the underlying groundwater is also used for irrigation. Some water also runs off the end of the field. Most fields in Kern County and much of the San Joaquin Valley capture this water in a 'tail pit' at the low corner of the field and pump it back to irrigate additional sets or other fields. So the farmer 'wasted' the 80 ac-ft for the surface irrigation of that one field, but it was not lost to the basin (Kern County, for example).

In fact, an analysis of long-term recharge to the Snake River in Idaho from the Eastern Snake River Plain showed a decline of about 3/4 MAF from 1970 to 2000 due to the conversion of ½ million acres of surface irrigated fields to more efficient sprinkler irrigation.

Excepting El Nino years and some areas with groundwater "banking" programs, average groundwater levels have been dropping throughout the Central Valley of California for the last 20 years – especially in the San Joaquin Valley. Between low rainfall and inflow of surface water from the Kern River, eastside Friant-Kern Canal and the California Aqueduct on the Westside, Kern County alone has had a running deficit of 0.2 to more than 1 MAF/year to meet crop demand. This deficit has been met through groundwater pumping and the decline in our groundwater levels reflects this.

Kern County On-Farm Irrigation Efficiency: From Fall 2000 through 2006 irrigation scheduling and soil moisture monitoring demonstrations and irrigation evaluations were conducted by the University of California Cooperative Extension in 132 fields over 11,994 acres with 30 different growers covering 14 different crops, 11 different soil textures and 9 different irrigation system types. Data collected from these sites indicated that the average on-farm application efficiency was 95%. Soil tests from these and many other Kern County fields show increasing salinity in the lower crop rootzone (mostly in micro irrigation systems) that corroborates this high level of efficiency – even to the point of causing toxicity and yield loss in some fields. For most of the Central Valley basins there is little, if any, "wasted" water to conserve.

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